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Research Article

Effect of Two Stocking Densities on Growth Performance, Litter Moisture Levels and Prevalence of Lameness in Broiler Chickens

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Abstract

This study assessed the effect of stocking density on growth performance, litter moisture levels and prevalence of lameness in broiler chickens. A total of 1500 1-day-old Cobb500 mixed-sex broiler chicks were randomly allocated to two stocking densities of 17 birds/m2 (high, HSD) and 11 birds/m2 (low, LSD) each with six replicate pens. Growth performance parameters were recorded at placement and then on weekly intervals. The walking ability of the birds was assessed on day 28 and 35 using the Kestin., et al. (1992) gait scoring system. Bodyweight and daily gains were higher in HSD birds, while feed intake was higher in LSD birds ($P > 0.05$), and birds on the HSD had the highest FCR ($P < 0.05$). Stocking density had no significant effects on litter moisture levels, although the frequency and severity of lameness was higher in HSD birds and increased with age. The highest lameness severity rate was 30% and 3% for LSD birds with gait scores of 2 and 5 respectively; and 29% and 13.3% in HSD birds with gait scores of 3 and 5, respectively. It was concluded that reducing the number of birds per stocking density has benefits for leg health and feed conversion efficiency in broiler chickens.

***Keywords**: Growth Performance; Space Requirements; Gait Score; Litter Quality; Welfare; Broilers*

Introduction

The manner in which broilers are reared has a direct effect on their performance levels and stocking density is one of the most important factors to consider [1]. In broiler production high stocking densities are usually associated with a decline of body weight, feed intake and conversion, uniformity amongst the flock and leg health [2]. In the commercial sector the stocking of birds per m^2 and the selection of an appropriate strain are of essential importance to ensure rapid weight gains as well as high feed conversion ratios [3,4]. However, many producers express stocking density as a mass per unit of space rather than numbers of birds being reared in a given area [5]. The European Commission [6] recommended a maximum stocking density of 30 kg/m^2 (0.073 m^2/bird) to meet the minimum welfare standards of broiler chickens across. From a profit point of view, when large numbers of birds are stocked per unit area farmers receive more profit per unit space, hence the rearing of birds in high numbers is a common practice in the broiler industry [7]. Furthermore, birds housed at higher stocking densities are likely to have reduced feed intake and weight gains than those housed at lower stocking densities [8].

Undesired consequences of rearing broilers under high stocking densities are leg health problem, bruising and low carcass quality that result in condemnations during processing, thereby reducing profit per chicken produced [9]. Often times, in such cases, the welfare of birds is relatively reduced especially during the final weeks of rearing affecting slaughter weights [10,11]. Lameness in broilers is usually assessed by examining the gait of individual birds using the Bristol gait scoring system that ranges from 0 (normal) to 5 (unable to walk), with 14% to 50% of broilers reported to suffer from lameness reflected by gait scores 3, 4 or 5 [12]. The quality of litter exacerbates the effects of poor stocking density, directly affecting growth performance, health, carcass quality and welfare aspects [13]. Litter moisture is the most likely culprit in the onset of footpad dermatitis in growing broilers and turkeys, impacting on poultry paw markets [14]; as it increases the risk of pathogenic growth and ammonia (NH_3) production [13]. At low temperatures (18.3°C) litter moisture can range from 37.4 to 40.4%, whereas a maximum between 46.8 and 51.1% at the upper limit temperature (40.6°C) is possible and above these critical moisture levels NH_3 generation decreases [15].

Objective of the Study

The objective of this study was to assess the effects of two stocking densities on growth performance, litter moisture levels and prevalence of lameness of intensively reared broilers.

Materials and Methods

Site description

The study was conducted at Fort Cox Agricultural College, Eastern Cape, South Africa. It lies along a longitude of 27° 1.644' E and a latitude of -32° 46.98'S at an altitude of 450 - 500m above the sea-level. It is located in the False Thornveld of the Eastern Cape Province characterized with a mean annual rainfall of 480 mm per annum and annual temperature of 18.7°C, with most rains in summer.

Experimental design and bird management

A total of 1500 day-old Cobb500 mixed-sex broiler chicks were randomly allocated to two stocking densities of 17 birds per m^2 (high stocking density, HSD) and 11 birds per m^2 (low stocking density, LSD), respectively; each with six replicates. Each pen served as an experimental unit. At placement, chicks' initial weights were recorded, and then weekly at 7, 14, 21, 28 and 35 days of age, respectively. Feed and water were freely available regardless of the stocking density.

Epol Optigro 3-phase feeding programme composed of starter (d 1-21), finisher (d 22-28) and post-finisher (d 29-35) was used in the study. The nutrient composition of the feeds is shown in table 1 below. Tap water at temperatures of 19.6ºC was used and its mineral composition, pH, total dissolved solids, electrical conductivity were measured (Table 2). Feed intake and bodyweight were measured weekly on a per pen basis. Feed intake (FI, g) was calculated as feed allocated minus feed refused; while bodyweight (BW, g) was calculated as final BW minus initial BW, and average daily gains (ADG, g) were calculated accordingly. The FCR was calculated as the FI (g) per BW (g) on a pen weight basis. Mortalities were recorded and the dead birds were weighed to adjust the feed conversion ratio. Chicks were reared on deep litter using sawdust as the litter material, spot brooding was used, and continuous fluorescent lighting was provided throughout the 35-day trial period. House temperature was set and maintained at 34°C during the first week and then reduced by 3°C per week until 22°C was reached and maintained at this level until the end of the experiment at 35 days. Care and management of birds were in accordance with principles of animal care in experimentation (NRC, 1985). The experiment was subjected to an assessment for its ethical acceptability and approved by the Ethics Committees of the University of Fort Hare.

Nutrient	Starter (0 - 21d)	Finisher (22 - 28d)	Post-Finisher (29 - 35d)
Protein % (min)	22.0	18.0	17.0
Total Lysine % (min)	1.2	0.9	0.9
Total Methionine % (min)	0.46	0.34	0.34
Moisture % (max)	12	12	12
Fat % (min)	2.5	2.5	2.5
Fiber % (max)	5	7	7
Calcium % (min)	0.9/0.8	0.8	0.7
Calcium % (max)	1.2	1.2	1.2
Phosphorus % (min)	0.6/0.7	0.5	0.5
Energy (MJ ME)	12.0	12.3	12.5

Table 1: *Feed specifications of the Epol Optigro 3-phase feeding programme.*
Adapted from Epol (2013).

Parameter	Normal tap water composition
pH	6.96
Electrical conductivity (EC)	124 us
Totally Dissolved Solids (TDS)	58.6 mg/L
Mineral composition	
Aluminum (Al)	0.29
Calcium (Ca)	14.07
Potassium (K)	6.82
Magnesium (Mg)	4.59
Sodium (Na)	20.55
Cadmium (Cd)	238.67
Chromium (Cr)	113.83

Table 2: *Mineral composition, pH, dissolved solids, and electrical conductivity in water.*

Measuring prevalence and severity of lameness

Gait or walking ability of the birds was assessed on day 28 and 35. The gait scores were assessed on 10 randomly selected birds in each pen. Two observers watched the birds and scored their walking ability on a six-point scale ranging from 0 (normal gait) to 5 (unable to walk) as described by Kestin., *et al*. [12] shown in table 3 below. The scores were ascribed only when the two observers were in agreement. However, since the scoring was performed in live birds, histology was not performed in the current study.

Gait scores	Indicative signs
0	Gait is smooth, the foot curls when it is lifted and the bird appears well balanced.
1	Gait is uneven. The foot may or may not curl when lifted.
2	Gait is uneven foot does not curl when lifted. The bird's stride is shortened, may have poor balance and use the wings for support.
3	Similar to gait score 2, but the bird remains lying down unless gently pushed to move. More likely to use wings for balance and support. The bird cannot stand for more than 15 seconds and typically lies down after a series of steps.
4	The bird is reluctant to move; a few seconds before the bird stands on both feet it uses wings like crutches and can only take a few steps before lying back down.
5	The bird cannot walk

Table 3: *Gait scoring criteria.*

Adapted from Kestin., et al. (1992).

Statistical analysis

Analysis of variance was used to determine significant water treatment effect and stocking density effect (SAS, 2003) on bodyweights (BW), feed intake (FI), feed conversion ratio (FCR), average daily gain (ADG) and prevalence and severity of lameness. When significance was indicated means were separated using Fisher's LSD (Least Significant Difference) procedure at $P < 0.05$.

Results

Growth performance, feed intake and average daily gain

The birds that were kept at an HSD showed significantly lower ($P < 0.05$) BW and ADGs than birds that were on an LSD (Table 4). Similarly, FI was highest ($P < 0.05$) in HSD birds compared to those on LSD, and the FCR was highest ($P < 0.05$) in LSD birds than those on HSD.

Treatment	Week			Parameter		
		BWG, g/kg	FI, g/kg	ADG, g/kg	FCR	LM
17 birds/m^2	1	136.67	119.63	13.12	1.16	27.43
11 birds/m^2		116.67	121.50	10.12	1.04	22.73
SEM		3.761	4.209	3.708	0.055	1.666
17 birds/m^2	2	354.97	290.93	31.19	1.24^b	41.45
11 birds/m^2		335.02	308.49	31.19	1.01^a	38.02
SEM		10.146	16.983	8.685	0.064	1.673
17 birds/m^2	3	738.83	574.35	54.84	1.30^b	39.59
11 birds/m^2		690.47	606.75	50.78	1.02^a	43.23
SEM		21.619	28.365	18.131	0.072	1.218
17 birds/m^2	4	1213.93	842.14	67.87	1.45^b	35.34
11 birds/m^2		1188.17	878.06	71.10	1.13^a	49.48
SEM		21.620	43.985	18.968	0.077	3.489
17 birds/m^2	5	1874.25	1057.14	94.33	1.77^b	47.16
11 birds/m^2		1758.87	1093.06	81.53	1.38^a	48.15
SEM		43.348	40.814	33.564	0.106	0.961

Table 4: *Effect of stocking density on growth performance and litter moisture of broilers.*
Means with different superscripts are statistically significant (P < 0.05). BWG: Bodyweight Gain; FI: Feed Intake; ADG: Daily Weight Gain; FCR: Feed: Gain Ratio; LM: Litter Moisture.

Effect of stocking density on litter moisture levels and frequency of lameness at different ages

There were no significant statistical effects observed in litter moisture (Table 4). The levels fluctuated between stocking densities. The walking ability of the birds was assessed on day 28 and day 35, results are shown in figure 1. On day 28, the birds at LSD had a lower frequency of 16.53% on lameness compared to the birds at an HSD with 19.67%. A similar trend was observed on d 35, the frequency of lameness being lower on LSD birds (16.67%) than birds on HSD (25.5%).

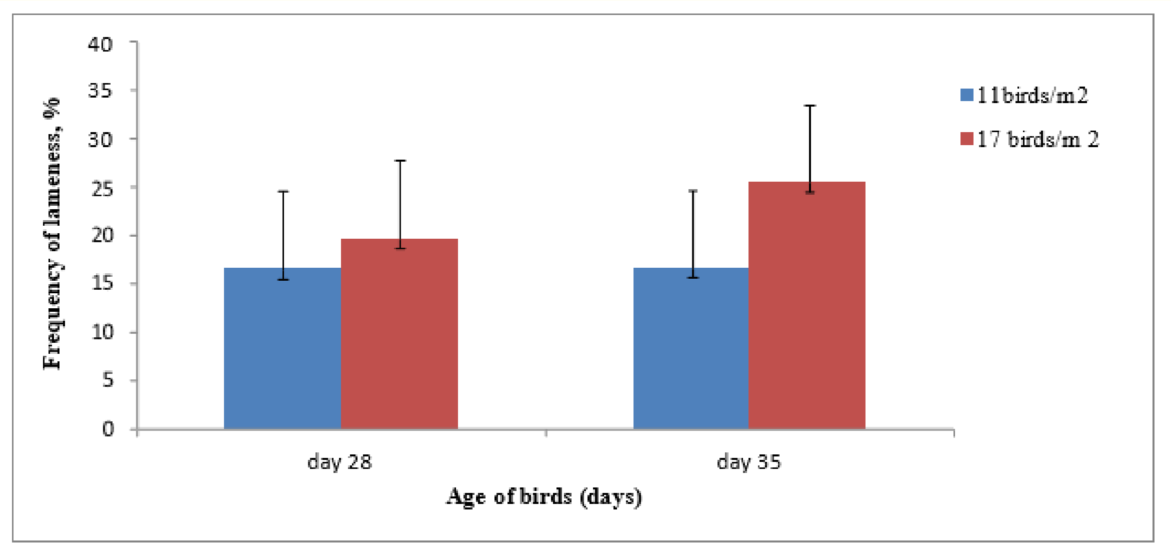

Figure 1: *Effects of stocking density on prevalence of lameness in broilers at day 28 and 35.*

Effect of stocking density on severity of lameness in the flock

The severity of lameness was assessed using gait scores [12], results are shown in figure 2. Birds at an HSD showed higher severity of lameness according to the gait scores that were assigned. However, the LSD pens had a higher frequency of birds that walked normally (score 0), were mildly affected (score 1) and those with uneven gait (score 2) compared to the birds at an HSD (Figure 2). There was a higher frequency of birds with a disturbed (score 3), severely disturbed (score 4) and completely lame gait (score 5) at an HSD compared to LSD (Figure 2).

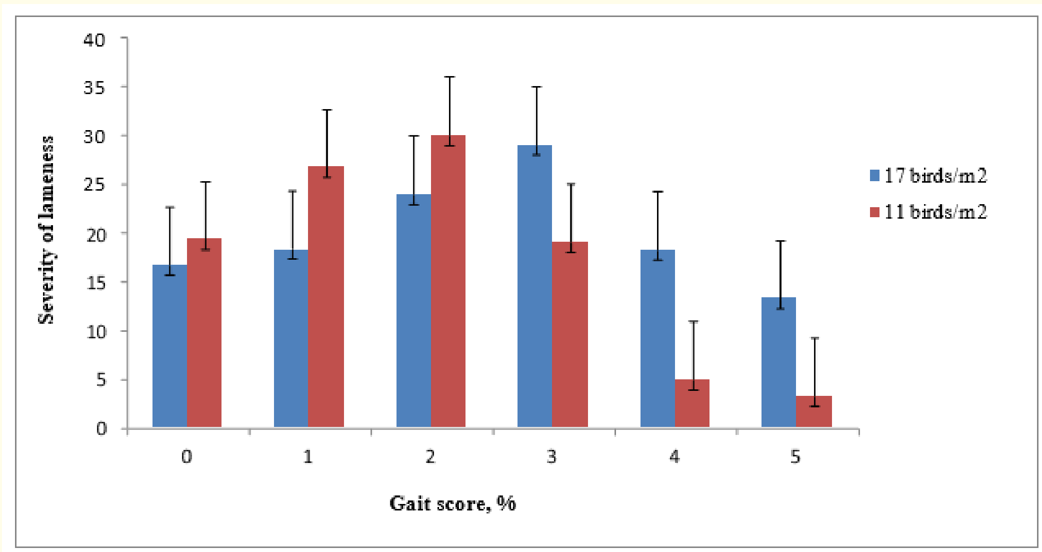

Figure 2: *Severity of lameness in broiler chickens reared at different stocking densities.*

Discussion

A clear association between lameness and stocking density was noted in the present study, although bodyweight gain was not affected by either lameness or stocking density, even as feed intake was lower for birds in HSD. Previous studies reported a negative effect of high stocking density on body mass gain [8,16-19]. This could be attributed to stress due to competition for feed and water [20]. In relation to the study by Estevez [7] feed intake and weight gain differences were attributed to competition for space and access to feed and water, whereas birds on lower stocking density had no difficulty in their feeding activity. Similar to a study reported by Mortari., *et al*. [17] a higher feed intake and feed conversion ratios under LSD was observed in the current study, compared to birds on HSD. In contrast, in several studies higher stocking densities resulted in better feed conversion ratios [8,16,19]. This can be explained by the fact that the birds were given feed at *ad-libitum* levels, which encourages the feeding activity and determines intake levels. Initiation and progression of the feeding activity depends on crop and gizzard capacity. When nearly empty the crop sends hunger signals to the brain to resume the feeding activity, but a partially full gizzard or ad libitum feeding discourages crop filling allowing feed to pass directly to the gizzard or proventriculus, thereby reducing feed conversion efficiency [21]. Alternatively, this could be attributed to feed wastage, since birds reared at lower densities have more space and time around the feeders, whilst those at higher stocking densities account for the feed they consume [16].

Broilers that receive more exercise have less leg weakness and better waking abilities [22]. There is a relationship between stocking density, exercise and leg weakness, birds at lower densities move around more and the expression of lameness is usually limited [20]. As observed in this study, birds at an HSD had a higher severity of lameness compared to the birds under LSD. The highest lameness severity rate was 30% and 3% for LSD birds with gait scores of 2 and 5, respectively; and 29% and 13.3% in HSD birds with gait scores of 3 and 5, respectively. These results are agreeable to the findings [12,23,24] that stocking density increases the severity of lameness in a flock, which they attributed to the limited amount of space and perking order of the birds. A direct association between age of birds and lameness was observed in the present study, as birds matured the prevalence of lameness also increased, due to the heavy bodyweight strain on leg bones. As shown in figure 2, the frequency of lameness at day 35 was higher than at day 28. The heavier bodyweight negatively influences their walking ability, which then results in lameness [7].

Legislative requirements focus on the moisture content and texture characteristics of the litter substrate, because the litter on which broilers are grown is one of the key factors influencing their performance and welfare [25]. According to the study by Martrenchar., *et al*. [10] litter quality tends to decline (wetness and caking) rapidly at high stocking density and as a result affect broiler performance. There were no significant statistical differences in litter moisture levels in the current study, fluctuations noted weekly between the two stocking densities. Enting., *et al*. [26] states that poor management practices and dietary factors such as mineral, carbohydrate, protein and lipid intake may cause wet litter. In this study, this was not the probable case, since all birds were offered the same water and feed, so only stocking density would have had an effect. Moreover, the depth of the litter also influences its absorption capacity, while a high bird stocking density will lead to poor litter quality [27-31].

Conclusion

Stocking density had a negative effect on the walking ability of broilers, but growth performance was not affected. Compensatory growth in birds under HSD could have been at play, hence the increase in bodyweights. Even though moisture levels were high in some HSD pens, NH_3 production was not a problem, probably due to the effective temperature control during rearing. It was therefore, concluded that reducing the number of birds per stocking density has benefits for leg health and feed conversion efficiency in broiler chickens.

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